PART I

Fundamentals of Disease and Insect Control

Losses Caused by Animal Diseases and Parasites

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GERMS AND WORMS and other low forms of life pick close to half a billion dollars a year from the pockets of our livestock producers, often so expertly that the producer does not even realize his loss. Here are enemies that must be fought with our very best strategy, based on research.

THE TRADITIONS of the oldest civilized nations show that they early recognized the importance of diseases among their animals and the danger these diseases meant to human health. Today, with a dense livestock population in many parts of the world, modern transportation facilities, and the daily concentration of large numbers of farm animals at hundreds of market centers, the opportunities for animals to become infected with diseases and parasites are greatly increased in comparison with those of the past. The prevention or control of these diseases and the protection of the public from exposure to those that are communicable to man have become complicated and costly.

The far-reaching economic consequences of animal diseases, parasites, and insects are frequently not understood or are overlooked. Most of us think little of the death of a chicken; yet the aggregate monetary loss from poultry diseases, involving mortality and nonproductivity among adult fowls as well as the death of young and growing birds, is incredibly high in the course of a year. Moreover, in many cases of disease, the losses are much more extensive than

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the direct loss due to the death of the affected animal or the depreciation in its value. Some diseases, such as cattle tick fever, have even restricted the whole agricultural program in the infected districts.

Some of the cost of disease prevention is chargeable to diseases that do not even exist in the United States but which in self-protection this country has to guard against by maintaining an effective quarantine service at ports of entry. The communicability to man of a number of animal diseases is well known, and this danger adds to the economic losses. The need for and the cost of meat and milk inspection are in large part due to the necessity of guarding the consumer against animal diseases that may be transmitted by these food products. Quarantines within our own country, which either prevent or restrict the movement of animals from a specified area, are important and necessary control measures, but generally they adversely affect the value of the healthy as well as the diseased animals within the quarantined area; and sometimes, as in an area quarantined on account of cattle tick infestation, even the land values may depreciate. For protection against other diseases, such as hog cholera, anthrax, and encephalomyelitis, enormous numbers of healthy animals have to be immunized each year. In addition to the monetary losses from contagious and infectious diseases, there are those resulting from sporadic diseases, poisonous plants, wounds, and injuries, which, taken together, amount to a very large sum. In fact, it has been estimated that the loss solely from shipping injuries to food-producing animals due to abuse, carelessness, or other preventable causes amounts to at least 11.5 million dollars annually.

The intangible or indirect nature of much of the loss due to animal diseases makes it impossible to calculate the exact amount in dollars and cents. However, it has been estimated to be nearly one-half of a billion dollars annually. In the never-ending fight to reduce this drain on the livestock industry, hundreds of scientific workers are constantly employed, both publicly and privately. Large sums are expended each year by the States and the Federal Government for the prevention, control, and eradication of diseases now present in the United States and to guard against the introduction of new diseases and pests from abroad.

The following examples of a few of the more important diseases and pests will serve to show the extent of some of these losses.

TUBERCULOSIS

The existence of tuberculosis among farm animals causes serious losses, partly because the disease is communicable between different classes of livestock. Swine, for example, readily contract the avian type of tuberculosis when exposed to poultry infected with the disease, and the susceptibility of human beings to tuberculosis of the bovine type has an important bearing on public health problems.

Much progress has been made in the control and eradication of tuberculosis in livestock during the last 24 years, as evidenced by the great reduction in the percentage of cattle that react to the tuberculin test and by the reduction in the number of carcasses and parts of

carcasses condemned for this disease at slaughtering establishments operating under Federal inspection. During the fiscal year 1941 approximately 12,229,500 tuberculin tests were applied to cattle by veterinarians under the direction of the officials conducting cooperative tuberculosis-eradication work. The percentage of cattle that reacted to these tests was 0.3, the lowest average degree of infection found in any year since the work was undertaken in 1917. The percentage that year was approximately 5, while the annual financial loss from bovine tuberculosis alone was conservatively estimated at 25 million dollars. Also during 1917 slightly more than 2 percent of all the cattle slaughtered in establishments operating under Federal supervision were retained for further inspection because some evidence of tuberculosis was shown on post-mortem examination. About 195,500 cattle carcasses were retained, of which about 41,000 were condemned as unfit for human food. On the other hand, during the fiscal year ended June 30, 1941, the percentage of cattle retained, exclusive of known reactors to the tuberculin test, was 0.07. About 8,000 cattle carcasses were retained, of which 1,584 were condemned as unfit for human food.

During the fiscal year 1917, evidence of tuberculosis was reported in approximately 10 percent of all the hogs slaughtered under Federal supervision, and about 168,000 carcasses, or 0.41 percent of the number slaughtered, were condemned as unfit for food or passed for sterilization. The percentage of retentions increased gradually up to 1924, when it was 15.2, an increase of about 50 percent during that period of 7 years. Since 1924 the percentage of retentions has gradually diminished; during the fiscal year 1941 it was 8.2, and the number of carcasses condemned and sterilized was 31,200, or 0.06 percent of the number slaughtered. Much of the tuberculosis now being reported in swine is of the avian type.

The cooperative tuberculosis-eradication work among livestock has consisted largely in the tuberculin testing of cattle and the removal of reactors to the test. Through the combined efforts of all State, Federal, and county livestock officials, breeders, dairymen, and others, it was possible to apply about 241,950,000 tuberculin tests to cattle in this country from 1917 to June 30, 1941; about 3,809,000 reactors were disclosed and disposed of for slaughter. All the counties in all the States had qualified as modified accredited tuberculosis-free areas on November 1, 1940, indicating that the disease was present in less than one-half of 1 percent of the cattle population.

The losses caused by tuberculosis in poultry are considerable each year, especially in 11 of the North Central States, owing to mortality, decreased egg production, and general unthriftiness.

OTHER DISEASES

Brucellosis exists among cattle to some extent in all parts of the United States, but it is much more prevalent in some localities than in others.

Considerable research work on the control of this disease had been accomplished in this country before 1934, and in some States quite

a large number of herds of cattle had been freed of it. In 1934 a cooperative eradication plan was put into effect. At that time it was estimated that approximately 10 percent of the dairy and breeding cattle over 6 months of age in this country would react to the blood-agglutination test used to diagnose the disease, and many writers estimated that the annual loss due to the disease from reduction in the calf crop, nonbreeding, and reduction in milk production was in the neighborhood of 50 million dollars. Many breeders of purebred cattle, who had spent a lifetime building up herds with animals of irreplaceable blood lines, were forced out of business by the presence of a virulent type of the disease.

Since 1934 the incidence of infection with brucellosis has been considerably reduced. A large number of herds have passed three tests showing no infection within a period of a year and have qualified as accredited brucellosis-free herds. Also, a considerable number of counties have qualified as modified accredited areas, indicating that in county-wide testing of all the dairy and breeding cattle over 6 months of age, not more than 1 percent of the cattle or 5 percent of the herds were found to be infected. In many of these counties the degree of infection is less than 1 percent.

Johne's disease, which affects ruminants principally, was identified in this country probably 35 or 40 years ago. The causative agent, a bacillus, is expelled through body excretions and can be easily spread from farm to farm in many ways, the most important of which, no doubt, is by the introduction of infected cattle into clean herds.

It is difficult to estimate the monetary losses due to Johne's disease, as it probably exists unreported in many localities. On the basis of information from various reliable sources, however, it is believed that the financial losses are approximately half a million dollars a year. The disease has not been reported in human beings, although medical authorities have reported a chronic dysentery with symptoms similar to those found in cattle affected with Johne's disease. No satisfactory treatment for the disease is known at present.

Cattle tick fever was once the most serious obstacle faced by the cattle owners of the South. During the last half of the nineteenth century cattle died from it by the thousands, and at the beginning of this century it was estimated to be taking an annual toll of 40 million dollars from the South. All attempts at medicinal treatment had proved ineffective in controlling these losses. Following the discovery that the cattle tick was the only natural carrier of the disease, however, it became evident that without the tick the disease would be of little importance and would probably die out. On this theory efforts to eradicate the cattle tick were undertaken in 1906 and have continued uninterruptedly up to the present time, with the result that the area quarantined for cattle tick fever has been reduced to about 1 percent of its original size and the disease is no longer considered a serious menace in the United States.

Probably no other infectious animal disease is so widespread as hog cholera, and few parts of the world where swine are grown are free from its ravages. Since the first report of its appearance in

Ohio in 1833, it has spread to every State in the Union. During certain years, notably 1887, 1897, 1913, and 1926, the disease seemed to flare up in a virulent form and was unusually widespread in the United States, with estimated monetary losses amounting to 65 million dollars for a single year. In recent years the extensive immunization of swine with anti-hog-cholera serum and virus has held losses to a lower level, but notwithstanding these extensive prophylactic measures hog cholera continues to be the most serious and destructive disease of swine. It is estimated that directly and indirectly the disease is still responsible for an average annual loss of about 12.5 million dollars to the swine growers of the country.

PARASITES AND OTHER PESTS

The losses from the depredations of parasites affect not only the producers of livestock but also the meat industry and some other industries that utilize certain animal products for commercial purposes. The greatest losses, however, are sustained by livestock producers in the form of unthriftiness in stock, debility usually associated with digestive and respiratory disturbances, stunting, and death of young stock and poultry. The unhealthiness in particular is a serious drain on the resources of livestock producers, since it involves the expenditure of rather large sums of money for medication to alleviate symptoms of sickness as well as waste of feed in unsuccessful attempts to promote growth and fattening of parasitized animals.

It is difficult to estimate the death losses from parasites because there is no machinery for collecting information of this sort. That such losses are considerable, however, is evident from the fact that parasitism in livestock and poultry is widespread in this country; that severe death losses, sometimes as great as 10 percent, occur quite frequently among all classes of stock and poultry; that the losses have been reduced sharply in special cases by resorting to control measures and effective medication; that it is the common experience of sheep producers that lambs cannot be raised successfully on the farm without resorting to periodic drenching or other treatment with medicinal preparations and without making provision for rotation or other methods of parasite control; and that successful swine husbandry involves a special system of management designed to hold in check infections with roundworms, lungworms, kidney worms, and the other parasites that are responsible for most of the unthriftiness and stunting so common in pigs in many parts of this country.

The losses due to unthriftiness and stunting are even more difficult to estimate than the actual death losses. It is known, however, from information published by various investigators, that the waste of feed in raising and fattening parasitized stock must be enormous. For instance, it has been determined that whereas an average of 3.1 pounds of feed produced a gain of 1 pound in 7 weeks in chicks protected from parasites, 4.5 pounds of feed was required to produce this gain in weight in parasitized birds. In extensive studies conducted some years ago on 150 farms in the Middle West on which effective parasite control for swine was practiced, it was found that

pigs with which these special precautions were taken were ready for market 7 weeks younger than the average age at which pigs in that area were usually marketed, and that at 4 months of age the pigs so protected weighed 28 pounds more than pigs that had become parasitized. In a recent study by parasitologists of the Bureau of Animal Industry it was determined that sheep that acquired even a moderate infection with nodular worms on a pasture over a period of several months weighed on an average 10 pounds less than comparable sheep on a similar pasture free from nodular worm larvae.

The losses sustained by the meat industry have been ascertained much more extensively and accurately than those occurring on the farm. In large sections of the South where pigs are commonly affected with kidney worms the average loss per pig due to condemnation of the liver, kidneys, and kidney fat and trimming of loins to remove worms and lesions is nearly 40 cents a head. Several years ago it was estimated that the losses due to the condemnation of sheep intestines (used for casings and in the preparation of surgical suture material) because of pathological conditions produced by nodular worms amounted to about $200,000 in one State. The annual loss on beef and sheep livers condemned under meat inspection because of parasitic infestations of various kinds may be conservatively estimated at half a million dollars a year.

In spite of the general paucity of information on which to base accurate figures, it may be estimated conservatively that the total losses from parasites of all kinds, including the cost of drugs to keep these pests in check and the labor and equipment involved in special systems of management for controlling them, are about 125 million dollars a year. Of this large total, it is estimated that the diseases due to protozoan parasites, of which coccidiosis is of greatest economic importance, exact an annual toll from the resources of farmers, stockmen, and poultrymen of about 10 million dollars, half of which is chargeable to poultry coccidiosis. Furthermore, the combined losses from liver flukes in cattle, sheep, and goats and from tapeworms in all classes of stock and poultry are estimated at 5 million dollars a year. The large bulk of the remaining loss (about 110 million dollars) is chargeable to nematodes, or roundworms.

Insects, mites, and ticks are responsible for tremendous losses among livestock of all kinds. Many of these pests act as disease transmitters, most of them carrying diseases accidentally. Some serve as intermediate hosts of disease organisms, that is, the organisms must pass through an essential cycle of development in the body of the insect. Insects damage livestock directly by causing loss of blood or destruction of tissue, and they irritate and worry the animals by their presence or their bites. The resulting losses take the form of increased mortality, lowered general condition, slower growth, increased feed consumption, lowered work output, and reduced quantity and quality of such products as milk, wool, and hides.

The constant and persistent attacks of such pests as horn flies, stableflies, and horseflies, and, to some extent, mosquitoes produce nervous reactions that often cause grazing animals to stop feeding and seek such shelter as may be found in streams and shady places.

Under such circumstances it is impossible for them to put on flesh, and consequently it is difficult to bring them to a marketable condition. In dairy animals there is a direct loss due to lowered milk flow. Death is sometimes caused by concentrated attacks of particularly vicious species. The buffalo gnat is notorious in some of the Southern States for its destruction of animals, especially mules.

Mosquitoes cause heavier losses among livestock than is generally realized. For the most part the losses are more or less intangible and incapable of being appraised in terms of dollars and cents; they are due chiefly to interference with the normal development and well-being of the animals. Along the Gulf coast cattle are frequently driven from their feeding grounds in the marshes into the open water by mosquito attacks. Deaths of cattle from the concentrated attack of the large mosquito (*Psorophora columbiae*) are a matter of record.

The common housefly annoys all classes of livestock by crawling about on them and feeding on the secretions of the eyes and body openings. It also is capable of transmitting certain diseases of livestock, such as mastitis. What is more important, this fly may contaminate milk and other dairy products with the germs of such human diseases as typhoid, dysentery, tuberculosis, and cholera.

The most extensive losses to the livestock industry caused by insects are those due to the attacks of species that penetrate the living tissues of the animal and derive their entire sustenance during their period of growth from the body of their host. Some of these, such as the cattle grub, or heel fly, the horse bot, and the head bot of sheep, spend the greater part of the year within the body of the host animal. All three of these insects occasionally attack man and penetrate the body or head tissues. They cause much suffering and make medical attention necessary.

The damage wrought by screwworms and blowflies on livestock is spectacular, and the losses are all too apparent. The primary screwworm will attack any animal on which there is an injury, however slight. Thousands of cases of screwworm injury occur each year in the South and especially the Southwest. The cost of treatment, added to the value of animals killed by screwworms each year, constitutes a very heavy loss, which has been estimated to be at least 5 million dollars annually in the United States.

Lice of various species attack practically all the domestic animals and cause varying degrees of loss. Goat lice retard the development of young goats, lower the quality of mohair, reduce the amount of the clip, and frequently cause death. Chicken lice reduce egg production to a marked degree and lower the vitality of the fowls. Mites, fowl ticks, and sticktight fleas supplement the attacks of lice on chickens, and the combined result is a heavy loss to the poultry industry. The loss caused by the attacks of lice on cattle, horses, and hogs is less tangible but no less real. At the least a heavy infestation means decreased vitality.

Mites producing scabies or mange are the source of varying degrees of loss. In sheep, infestations of scab mites result in the loss of large

quantities of wool by shedding, and heavy infestations may so weaken the animals that they may die. Mange mites produce an unhealthy condition in other animals which in extreme cases may destroy their usefulness. The expense of enforcing quarantines against scab and mange is by no means a small item. Fortunately losses in this country from these mites have been greatly reduced in recent years by dipping operations.

Certain insects and allied classes of arthropods, such as ticks, transmit diseases to animals and are thus chargeable with the losses caused by these diseases. Outstanding in this group is the cattle tick, which transmits tick, or splenetic, fever of cattle. Anthrax is transmitted from animal to animal by biting flies and may be transmitted to man in the same way. Anaplasmosis is likewise transmitted by ticks and certain insects, and equine encephalomyelitis has been shown to be transmitted by mosquitoes. Buffalo gnats transmit the leucocytozoan disease of wild and tame ducks and a similar disease of turkeys. In Michigan some severe losses of ducks have occurred, and apparently heavy losses among young turkeys result from this malady.

Various parasitic worms of animals pass an essential stage of their existence in the bodies of insects. Without the insects as intermediate hosts they would never reach the stage where they can become animal parasites.

Finally, insects that destroy forage are responsible for considerable loss of livestock feed. The devastation of ranges by grasshoppers within the last few years has cut rather deeply into the profits from stock raising in the affected regions.

A TABULATION OF LOSSES

A conservative estimate of annual losses from the more important diseases, parasites, and pests of livestock and poultry, as of January 1, 1942, is included in the following tabulation:

Internal parasites	$125,000,000
External parasites of poultry	85,000,000
Cattle grubs	65,000,000
Poultry diseases (except tuberculosis and those caused by parasites)	40,000,000
Brucellosis of cattle (Bang's disease)	30,000,000
Mastitis	19,000,000
Hog cholera	12,500,000
Tuberculosis (cattle, swine, and poultry)	10,500,000
Swine abortion	10,000,000
Stablefly and horn fly	10,000,000
Screwworms	5,000,000
Cattle and sheep scabies	1,000,000
Encephalomyelitis	1,000,000
Swine erysipelas	1,000,000
Anthrax	750,000
Johne's disease	500,000
Hemorrhagic septicemia	500,000
Goat louse	500,000
Cattle tick fever	400,000
Rabies	250,000
Anaplasmosis	100,000
Total	$418,000,000